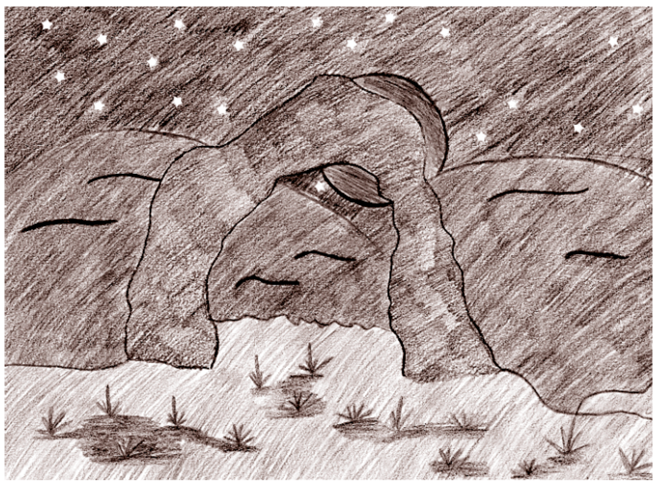
Physical Features of the earth



MICHELLE SAGGBOY

Outline

Theme
Geologic processes are dynamic, and cause continuous changes in the earth's physical features.

Utah State Science Core Curriculum
Topic: Physical Features of Earth
Standard [3050-01]: *Students will compare and contrast changes in physical features of earth over time.*

Suggested Field Trip Location
Bloody Mary Wash, immediately west of the Arches National Park Visitor Center parking lot. This site is unique in having a fossiliferous limestone in the wash bottom and a beautifully exposed geologic fault. All stations could be adapted for various geologic settings in southeastern Utah, but perhaps nowhere would have all the combined features of this site. An extra station is included to increase the flexibility of adapting this field trip to other locations. If you do use the suggested site, consider planning extra time to see the Arches National Park introductory slideshow at the Visitor Center.

Background

The rock layers and fault exposed at the entrance to Arches National Park are of textbook quality. The layers are easy to see; they have different colors as well as different compositions.

By looking at the rocks close-up, we learn about the ancient environments in which the sediments of the rock layers were deposited. Most mudstones and siltstones formed in low-gradient stream or tidal-flat environments. Some sandstones were deposited in steeper streams or on beaches. Sandstones made up of very rounded sand grains that are all the same size (well-rounded and well-sorted, in geological terms) indicate aeolian or windblown deposition, in a relatively dry environment. Limestones usually indicate a marine environment, and many contain fossils. (A few thin limestone layers in southeastern Utah were deposited in freshwater lakes.)

Instructor Mary Moran and the exposed face of the Moab Fault near the entrance to Arches National Park.

Any plant or animal that dies on earth can be fossilized if the conditions are correct. In order for a creature, or evidence of a creature, to be preserved as a fossil, the creature cannot be broken down or disintegrated. Many fossils are formed at the bottom of oceans, where deposition is occurring all the time, and dead organisms are quickly buried. This, and the fact that many marine creatures have hard shells that don't decompose easily, is why most fossils found are of marine organisms. Fossils of land-dwelling creatures are less common. The Honaker Trail Formation, found in the bottom of Bloody Mary Wash, contains an abundance of fossils. This limestone layer was deposited in an offshore marine environment, about 300 million years ago. There are fossils of crinoids, brachiopods, bryozoans, horn corals, and occasional clams, snails and trilobites.

A geologic fault is a break or fracture in the rock, along which there is displacement of the strata. Most faults form during earthquakes or volcanic activity associated with the shifting of tectonic plates. But here in southeastern Utah, much faulting is associated with an unusual phenomenon: the movement of underground salt layers. Faults are commonly buried by sediment and difficult to see, but the Moab fault is spectacularly exposed in Bloody Mary Wash. The Honaker Trail Limestone has been shifted 2,500 feet upward on the west side of the fault, past seven other rock layers. It is now on the same level as the Entrada Sandstone (Dewey Bridge Member) east of the fault.

Arches National Park's erosional landscape of valleys, towers, fins, canyons, pinnacles, and arches began to form about 10 million years ago. That's relatively young in geologic terms; the rock layers in the park were deposited roughly 300 million to 150 million years ago.

Based on the definition of an arch as an opening at least three feet across in one direction, there are over 2,000 named arches in Arches National Park. Most are within the Entrada Formation. Water is the main culprit in arch formation. Rainwater is usually slightly acidic, which weakens the cement between grains in the sandstone. The process of frost wedging involves water freezing (expanding) and thawing (contracting) in pores and cracks. This process is key in breaking apart sand grains, and especially prevalent with the large temperature fluctuations of the high desert climate. Wind and gravity remove weathered parts. Arches can be classified by their shapes, falling into categories including free-standing arches, cliff-wall arches and jug-handle arches. Natural bridges, unlike arches, are formed by flowing streams.

Plate tectonics is the driving force for most faulting and earthquakes, and for the melting and pressure that recycles rocks into new igneous and metamorphic rocks. The Earth has several layers: crust, mantle, outer core and inner core. The lithosphere, which is the crust plus the upper part of the mantle, is broken up into different pieces called plates, that move around in different directions on the Earth's surface. There are three basic types of boundaries between these plates. Convergent boundaries are where plates crash together. In this case, one plate usually descends beneath the other. Plates made up of oceanic crust are thinner and heavier, so they sink below the lighter, thicker continental plates. Friction here causes massive pressure, earthquakes, faulting and mountain building. The descending plate melts, only to rise up as a liquid magma and form volcanoes along the edge of the overriding plate. In a few cases when both of the lithospheric plates are made up of continental crust, neither plate descends, and the earthquakes and faulting create massive mountains such as the Himalayas. Divergent plate boundaries or rifts, where plates spread apart, are usually in the middle of oceans. Basaltic lavas flow from these boundaries, creating new crust. Transform plate boundaries, where plates slide by each other, are illustrated by the San Andreas fault in California. Friction at these boundaries creates earthquakes and faulting.

PRE-TRIP ACTIVITY

A journey from rock to rock

PROCEDURE

1) Write *Geology* on the board and define it as the study of the Earth's history. Inform students that geologists study the earth by looking at rocks, particularly those rocks found very near the Earth's surface. Ask if anyone has a rock collection. There are many kinds of rocks; geologists group them into three types, based on how they formed. Tell students that they will be looking at and classifying a rock in a few minutes.

2) Ask students to name the three major types of rocks: *igneous*, *metamorphic* and *sedimentary*. Discuss each. The names give clues about how they form: *Sediments* make up sedimentary rocks, *metamorphosis* means changing form (as in insect life cycles), and they can think of *ignite* for igneous.

3) Pair students. Pass out a rock to each pair, just for them to look at. After half a minute, have them pass their rocks. Do this at least two or three times. Then pass out copies of **What type of rock do you have?** and go over them. Have each student pair classify the rock they currently hold. After a couple minutes, ask each pair how they classified their rock, and discuss.

4) Lead a discussion of the rock cycle. Ask students what would happen to their rock in different instances, such if their rock was buried so deep that it melted, or their rock eroded into sand grains and then was re-deposited. Draw the rock cycle on the board, explaining that unlike many cycles, this one can go in any direction. Introduce the sandstone rock cycle as a cycle within the larger complex rock cycle by asking someone with a sandstone what type of rock they would turn into if they were broken into sand grains, moved downstream, re-deposited and hardened. The answer is *sandstone*. Use **The Sandstone Rock Cycle** poster to reinforce this last concept.

5) Inform students that they live in a fantastic place for exploring rocks. Tell them that they will be looking at sedimentary rocks near the entrance to Arches National Park on this field trip, and exploring how the rocks formed and the changes they have gone through.

6) Review field trip expectations and the items students need to bring on the field trip.

Objectives

Students will be able to:
- Name the three main types of rocks.
- Describe the rock cycle and the changes it represents.

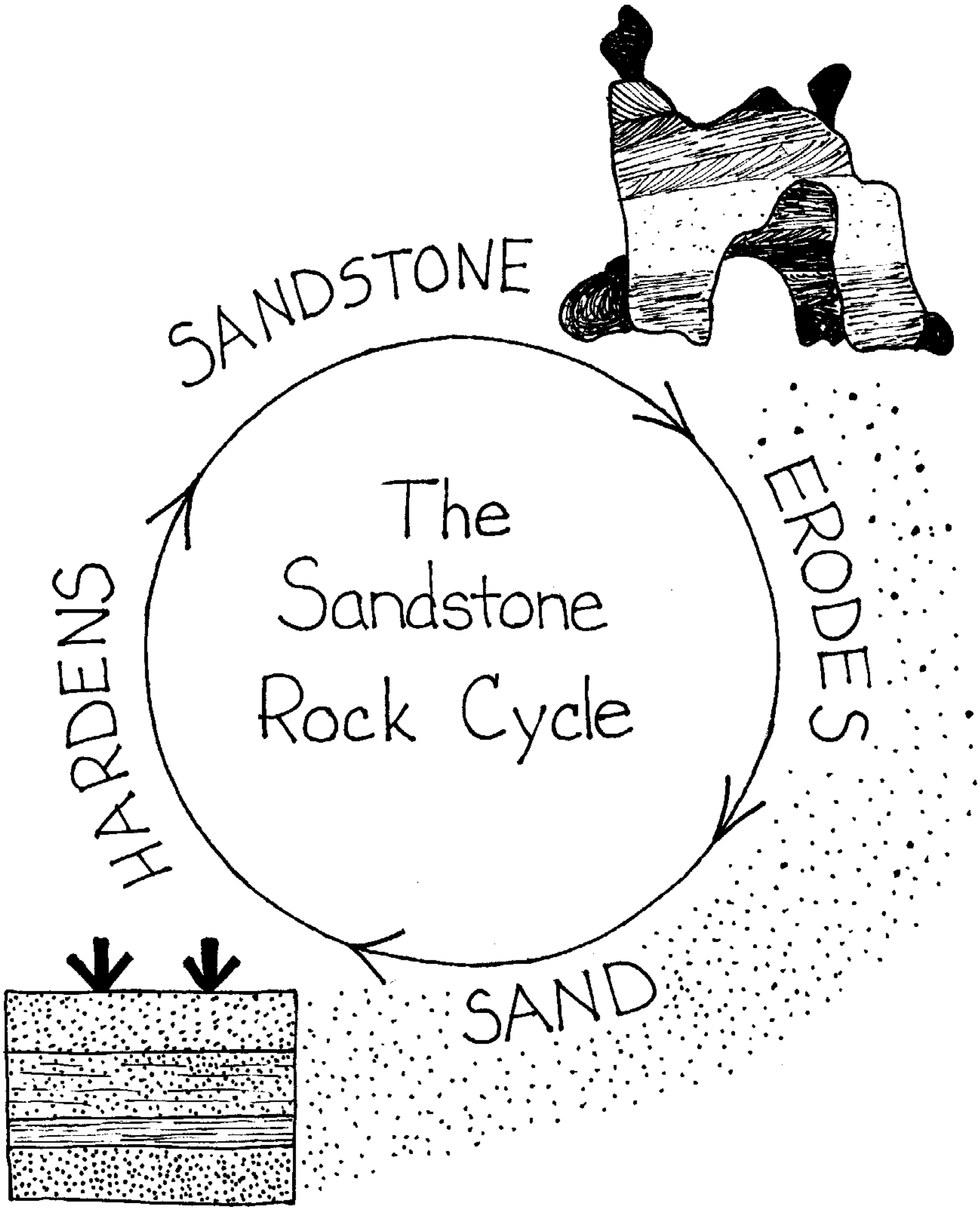
Materials

- Rock hand samples, including all three rock types
- Hand lenses
- Copies of **What Type of Rock Do You Have?**
- **The Sandstone Rock Cycle** poster

Time

- 35-45 minutes

PRE-TRIP


SANDSTONE
The Sandstone Rock Cycle
ERODES
SAND
HARDENS

What type of rock do you have?

SEDIMENTARY ROCKS

Formed when weathered and eroded sediments are deposited by water or wind and then buried and cemented.
Look for:
- rounded grains in layered rock
- fossils in limestone
- usually chips apart easily

IGNEOUS ROCKS

Formed when liquid magma crystallizes.
Look for:
- interlocking angular crystals that are not layered
- large crystals if slow cooled
- small or no crystals if quick cooling, or small gas holes

METAMORPHIC ROCKS

Formed when sedimentary, igneous or metamorphic rocks are subjected to heat and pressure.
Look for:
- usually extra hard
- flattened minerals in bands or wavy lines
- sheet-like texture, sometimes

What type of rock do you have?

SEDIMENTARY ROCKS

Formed when weathered and eroded sediments are deposited by water or wind and then buried and cemented.
Look for:
- rounded grains in layered rock
- fossils in limestone
- usually chips apart easily

IGNEOUS ROCKS

Formed when liquid magma crystallizes.
Look for:
- interlocking angular crystals that are not layered
- large crystals if slow cooled
- small or no crystals if quick cooling, or small gas holes

METAMORPHIC ROCKS

Formed when sedimentary, igneous or metamorphic rocks are subjected to heat and pressure.
Look for:
- usually extra hard
- flattened minerals in bands or wavy lines
- sheet-like texture, sometimes

Objectives

Students will be able to:
- Name sand grains as the main component of sandstone.

Materials

- None

Time

- 30 minutes

INTRODUCTORY ACTIVITY

Rock and roll

Adapted from Fluegelman 1976, 69

PROCEDURE

1) This game works best with six to ten people. Have students stand elbow-to-elbow in a circle, and tell them to imagine they are sand grains.

2) Instruct students to step forward and each grasp two hands, of two different people, with their hands. Once they have all completed this step, tell them to imagine that they have now hardened into sandstone.

3) Guide students in untying the knot they have made, without letting go of each other's hands. This involves climbing between arms, stretching in unusual ways, and laughter. As they begin to untie, orally create the image of rain, frost wedging, and erosion of the sandstone.

4) Once they are standing in a circle hand in hand, have them drop hands, becoming individual sand grains again.

INTRO

STATION ONE

Fossil frolic

PROCEDURE

1) Show students the poster of the ancient marine environment, and explain that this is about what it looked like here 300 million years ago. Briefly explain that environmental conditions change slowly through time, partly because of plate tectonics. This spot was near the equator, and the sea was shallow, allowing sunlight to reach the bottom and many creatures to live here.

2) Show examples of fossils. Have students find the creature in the poster that corresponds to each fossil. Briefly discuss each fossil creature, disclosing how the creature lived or how to recognize the fossil. For example, explain that crinoids were animals rooted on the ocean bottom, and were filter feeders. (Have students suck air in between clenched teeth.)

3) Save much of the time in this station for finding fossils. Give boundaries, and reinforce that students may look at and show others fossils that they find, but they are not to take any. Be sure to bring reference books with you and have an idea of what you'll be finding. Guide students to some rich fossil areas to get them started in their search. Share their enthusiasm.

4) Gather students and have them stand in a circle for a game that strongly reinforces the names of the common fossils in the area. Have an example of each of these fossils, for the A What? game. Direct the first round of the game. First show a brachiopod, for example, and hand it to a student to your right (student A) and say "This is a brachiopod." Instruct that student to ask "a what?" Respond, "a brachiopod." Then have student A pass the fossil to the student to her right (student B), saying, "This is a brachiopod." That student responds "a what?" and then student A turns to you and says "a what?" You respond " a brachiopod." The "a what?" question must always come back around to the person who first passed the fossil, and then the answer ("a brachiopod") must be passed all the way back to the student holding the fossil. Continue until the brachiopod comes all the way around the circle, and then start a different fossil. After two or three rounds, start two fossils at the same time, going in opposite directions around the circle.

EVALUATION

Have students name three kinds of fossil creatures and tell something about how each lived.

Have students describe the environment in which these creatures lived.

OBJECTIVES

Students will be able to:
- Name three types of marine fossils.
- Describe the environment in which the limestone was deposited.

MATERIALS

- Fossils
- Fossil field guides
- "What was it like here 300 million years ago?" poster (enlarged illustration from Rhodes, Zim, and Shaffer 1962, 42)

TIME

- 30 minutes

STATION 1

OBJECTIVES

Students will be able to:
- Define a geologic fault.
- Describe how the rock layers moved along the Moab fault.

MATERIALS

- **Fault Definition Cards**
- **Fault Cross-Section**
- Plastic knives
- Clay
- Cardboard bases for clay work

TIME

- 30 minutes

STATION 2

STATION TWO

Who's fault is it anyway?

PROCEDURE

1) Seat students in limestone amphitheater. Hand out a **Fault Definition Card** to four students. Have students take turns reading their definitions. Ask which definition they think we'll be exploring in this station. Give some additional explanation of geologic faulting.

2) Walk students over to the fault area. Have them put their faces against the fault. Have them step back and describe the rock. Point out the slickenside scratches on the rock, which resulted from the movement of the rocks past each other along the fault. To demonstrate the rocks' movement, have students press their hands together and move one past the other. Explain that this is the action of a fault. Show the students this action with the **Fault Cross-Section**.

3) Tell students that they will be making their own rock layers out of clay, and then faulting them. Distribute cardboard workboards, and one color of clay at a time, and have students make one flat layer on top of another. After they have made at least two or three layers, have them cut the layers at a steep angle to form a fault plane. Have students move the clay so that the rock layers move past each other along the fault. Make appropriate rock crushing noises!

EVALUATION

Have students create a fault using earthen materials.

EXTENSION

Assign students to research and make models of different types of geologic faults.

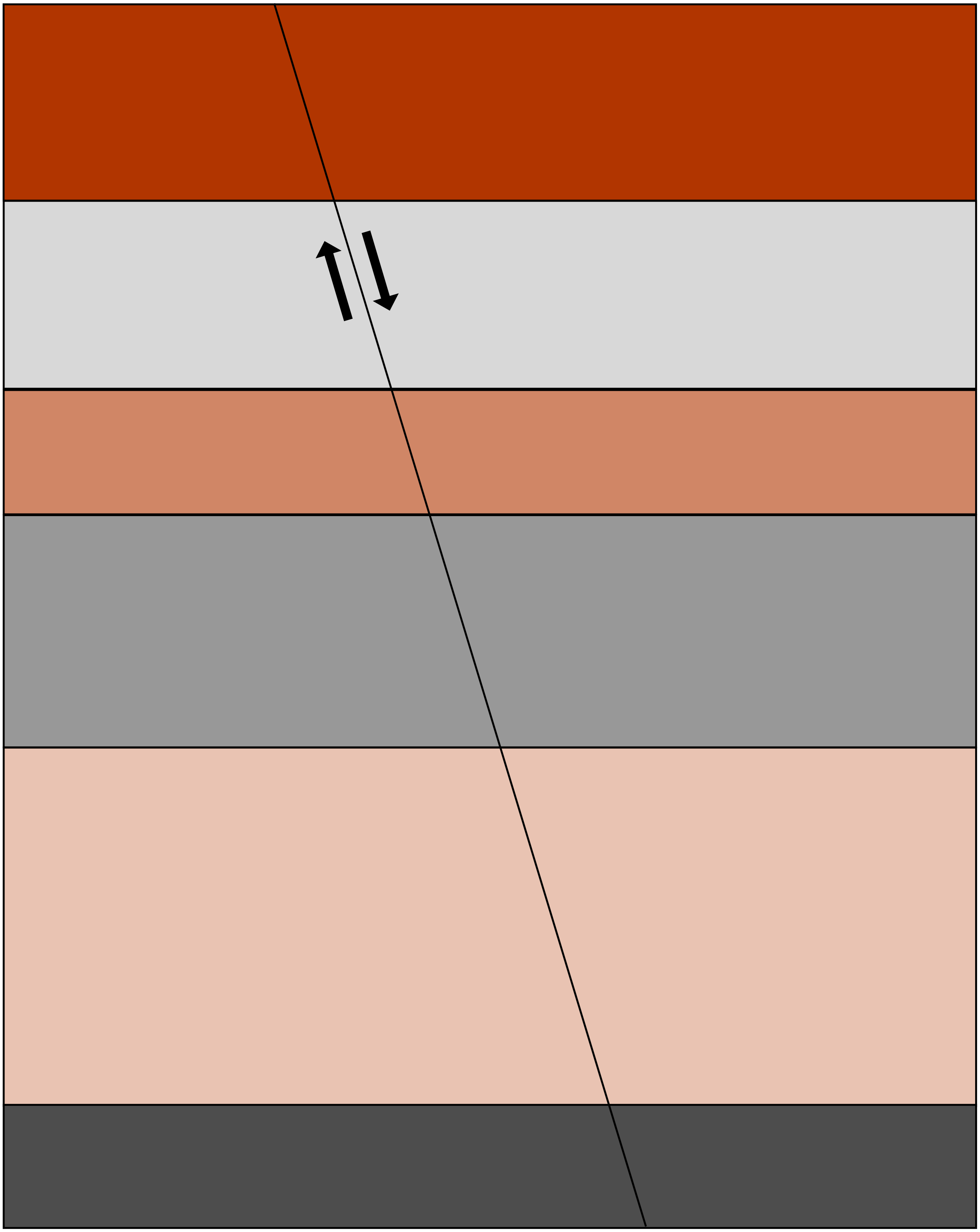
FAULT DEFINITION CARDS

Cut apart along lines.

Fault: Responsibility for something wrong	**Fault:** A mistake or small violation
Fault: A bad service, as in tennis	**Fault:** A break in rocks along which the rocks have moved.

FAULT CROSS-SECTION

Print on tagboard or glue printed paper to cardboard, then cut out block and cut block into two pieces along the diagonal fault line.



Objectives

Students will be able to:
- Name three types of arches.
- Describe two weathering processes involved in arch formation.

Materials

- Deep tray of moist sand
- **Types of Arches** (preferably enlarged)
- Postcards or photographs of specific named arches
- Paper, pencils and clipboards
- Cardboard strips (for relay) with names of three types of arches

Time

- 30 minutes

STATION 3

STATION THREE

Falling arches

PROCEDURE

1) In the Arches National Park Visitor Center, review the rock cycle, and be sure the students know that the rocks in Arches are all sedimentary rocks. Introduce arches as the subject of this station. Inform students that there are over 2,000 named arches in the park, and go over the size definition of an arch. Using the displays, show students that most arches here are in the sandstone layer called the Entrada Formation. Go over the processes involved in arch formation, including chemical weathering by rainwater, frost wedging, gravity, and wind. Emphasize that water is the main factor in arch formation. Contrast arches with natural bridges.

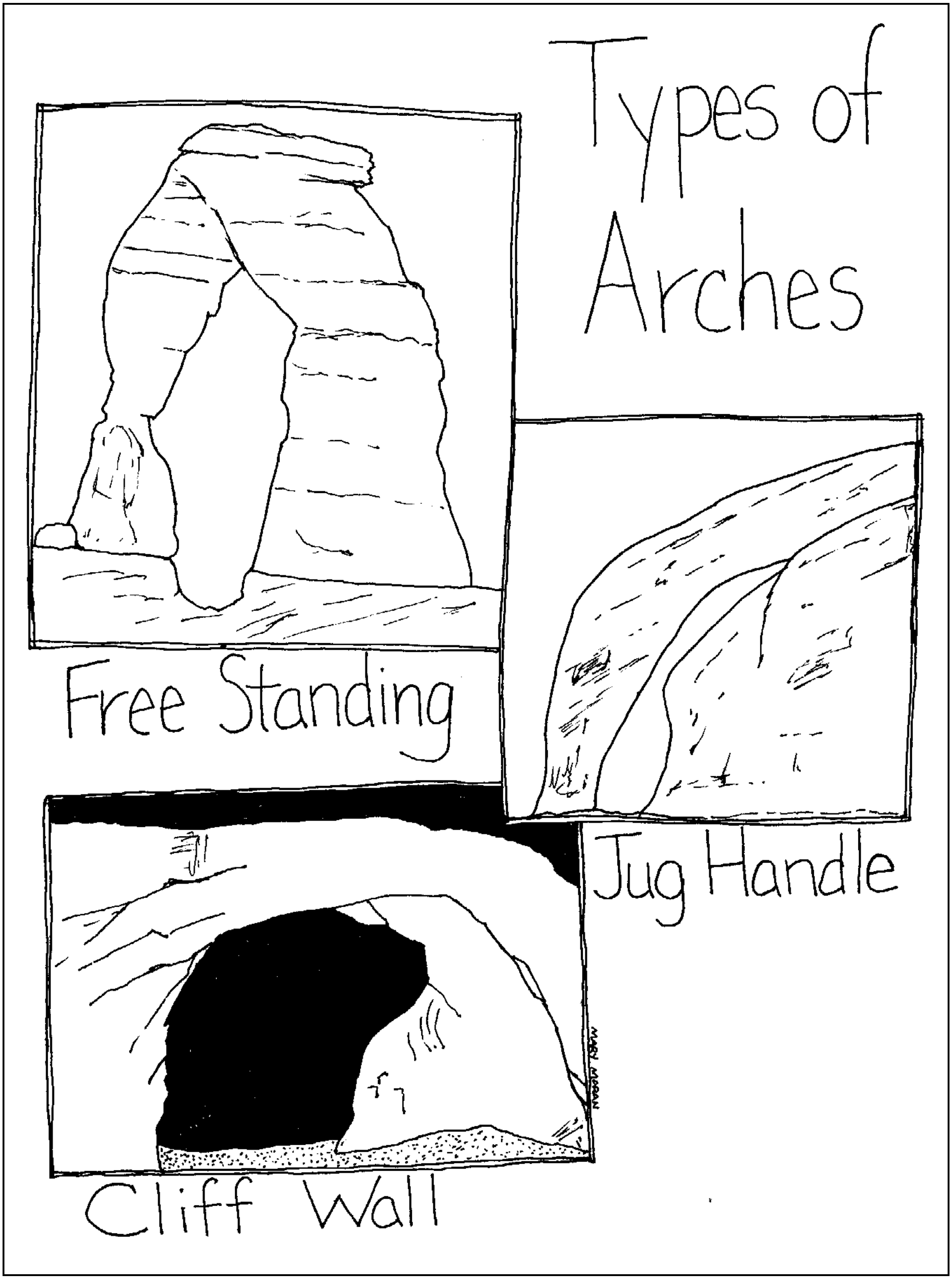
2) Outside, use the moist sand to demonstrate arch formation. Introduce different types of arches, showing the **Types of Arches** poster, and modeling them in the sand. Ask students the names of any arches they've seen and ask if they can figure out which types of arches they are.

3) Have each student choose one of the postcards (or photographs) of specific named arches, then read the arch name, show the card to the group, explain why they think that arch was given its name, and place the card by the correct type of arch on the **Types of Arches** poster. Hand out paper, pencil and clipboard to each student. Have each draw an imaginary arch, name it, write what type of arch it is, and present it to the group.

4) Choose one of the following review activities:

- **Human Arches**
  Keeping the **Types of Arches** poster visible, pair students, and whisper an arch type to each pair. Instruct pairs to create their arch type with their bodies, joining hands, kneeling, or whatever works! Have each pair show their arch while the rest of the group guesses which type it is. If time allows, have the group work together to make one last human arch.

- **Arch-Type Relay**
  Divide the group into two teams, in two lines. Show a postcard of an arch and read its name, then say "go!" Instruct the first person in each line to run to a pile of cards, each with one of the three arch-types printed on it. The goal is to pick up the correct card and run back to their team members. The first runner back gets a point for their team if they have the correct card. If not, the other team has a chance to get a point if they have the correct card. Play until time runs out or the students are exhausted.


Types of Arches
Free Standing
Jug Handle
Cliff Wall

Objectives

Students will be able to:

- List three of the rock layers in Arches National Park.
- Describe three environments in which the rock layers were deposited.

Materials

- **Rock Layers and Environments**, enlarged to poster size
- Pictures of environments: *Ocean*, *Tidal Flats*, *Stream*, *Sand Dunes*
- Laminated formation names
- (optional) Rock samples from each of the layers

Time

- 30 minutes

STATION FOUR

Picture this

PROCEDURE

1) Point out the relatively flat layers of the surrounding rocks, correlating different layers with the layers on the **Rock Layers and Environments** poster. Use food analogies for recognition, such as Navajo whipped cream and Entrada cherries east of the Visitor Center, and a few chunks of Kayenta peanut brittle atop the Wingate cliffs on the western skyline. Point out the slope of the Chinle, Moenkopi and Cutler formations. (It is difficult to distinguish the three here.)

2) Have students line up from oldest to youngest. Discuss the concept that each of the rock layers began as sediments being deposited in different environments. Using the poster, hand the oldest formation name to the oldest student, pointing out the layer and its look, and discussing and handing a picture of the environment in which it was deposited to the student. Repeat for each formation, encouraging students to be experts on their formations. Emphasize the huge amounts of geologic time involved. If you have rock samples, hand those to corresponding students as well, and reinforce the understanding of superposition by having students attempt to stack their rocks, with the oldest formation on the bottom and the youngest on the top. To review, ask each student what type of environment existed when his layer was deposited.

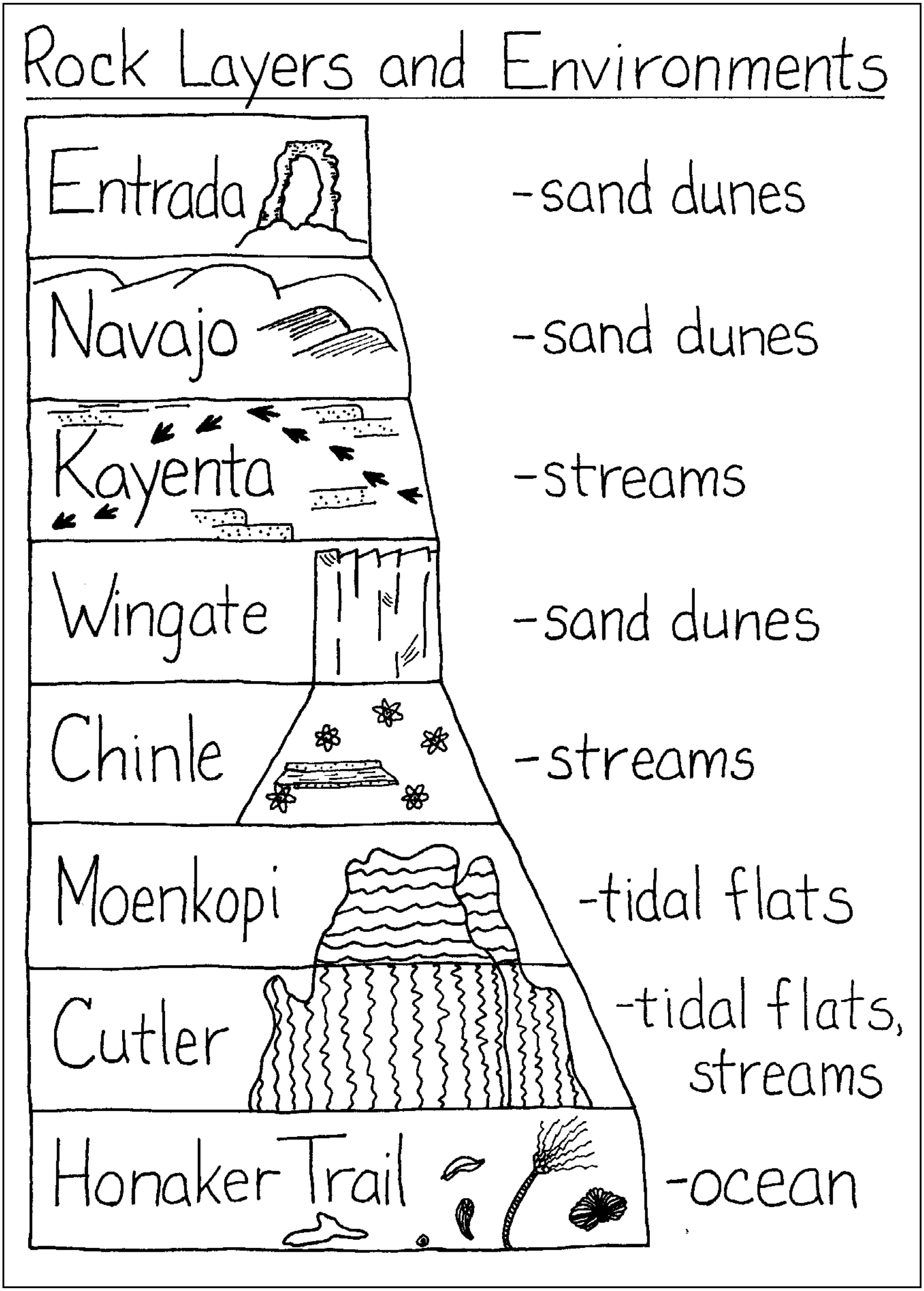
3) Reinforce these layers and their names with a relay. Place formation names 25-50 feet from a starting line, and have students line up in two teams. Instruct the two starting runners to retrieve the correct formation name based on a clue that you give. Instruct other students to help out by whispering (or shouting) the answer to their team runner. The first runner back with the correct formation wins a point for her team, and goes to the back of the line. Vary the clues to relate to environment of deposition, what the layer looks like, or the layer's age relative to other layers.

EXTENSIONS/VARIATIONS

Have students draw a profile of the wall east of the Visitor Center, labeling the depositional environment of each layer: *stream*, *sand dune*, or *tidal flat*. (There are no layers representing ocean environments east of the Moab fault.)

Have students create displays of rock layers and the environments they represent, using three or four flavors of pudding for the different environments. Ask them to write paragraphs about their displays, describing the plants, animals and climate in each environment.

STATION 4


Rock Layers and Environments
Entrada
-sand dunes
Navajo
-sand dunes
Kayenta
-streams
Wingate
-sand dunes
Chinle
-streams
Moenkopi
-tidal flats
Cutler
-tidal flats, streams
Honaker Trail
-ocean

Objectives

Students will be able to:
- Describe the changes that might happen in their lifetimes, to the exposed layers of rock.
- Describe the sandstone rock cycle.

Materials

- **The Sandstone Rock Cycle** poster (see Pre-Trip Activity)
- Copies of **Traveling Through the Sandstone Rock Cycle**
- Paper; clipboards
- Colored pencils
- Eyedroppers

Time

- 30 minutes

STATION FIVE

Sandstone re-cycle

PROCEDURE

1) Introduce the sandstone rock cycle using **The Sandstone Rock Cycle** poster. Briefly discuss geologic time and the long times involved in this cycle.

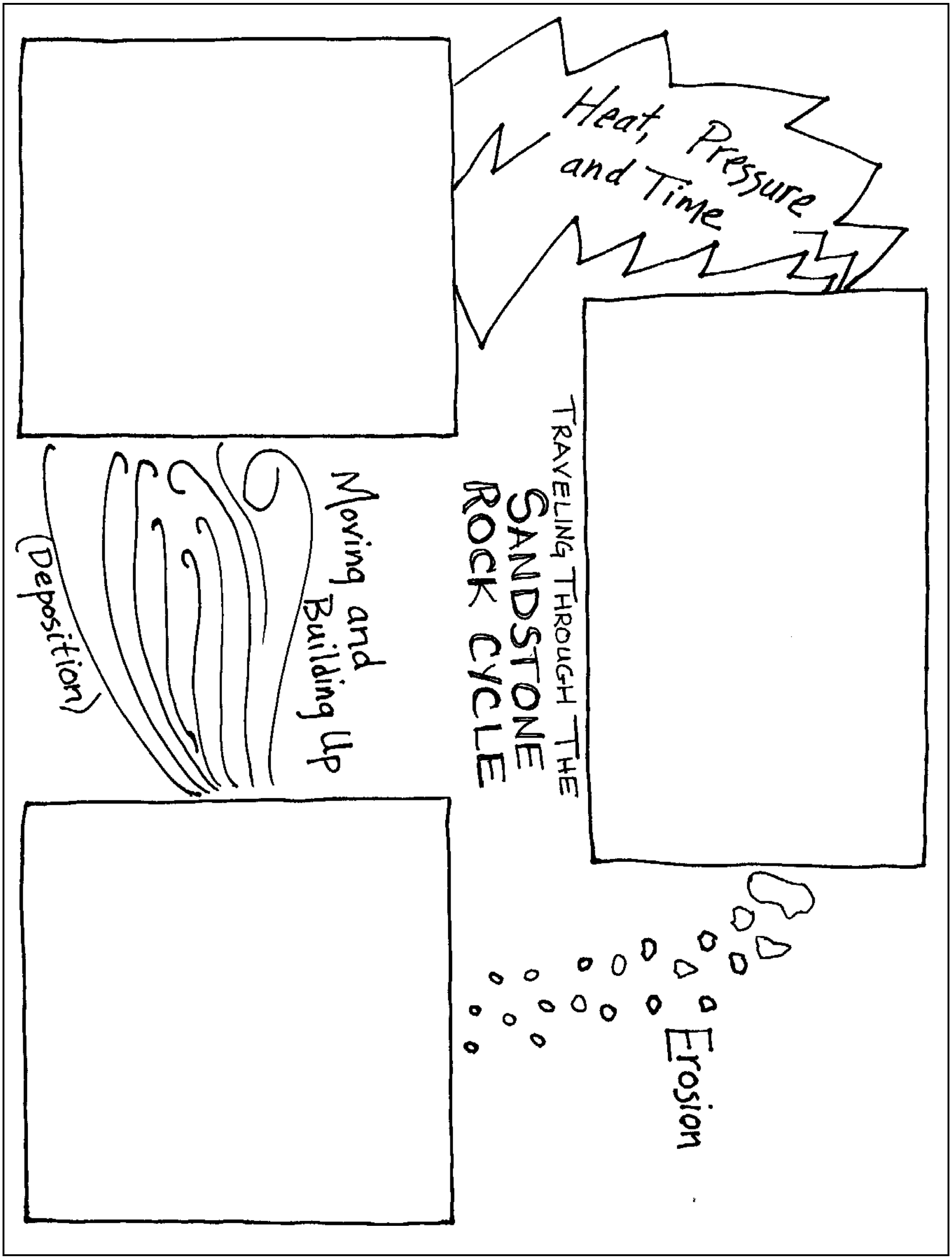
2) Ask students to take one minute to choose a small, hand-sized unique rock from the immediate area, and bring it back to the group. Discuss weathering and erosion, and have students demonstrate the processes on their own rocks, eroding their rocks by rubbing with other rocks, blowing on rocks to simulate wind, and using eyedroppers to simulate weathering and erosion by water. Discuss transportation of sand grains downstream, and the colors that the Colorado River turns after rainstorms. Have students imagine what it's like to walk through a windstorm to illustrate the lesser, but important, role that wind plays in transporting sediments. Discuss deposition of sediments, usually in low-lying flat areas. Look at the flat layering of the surrounding rocks. Discuss the hardening process, and reinforce by having students build a big pile of sand. To illustrate the long times involved in the hardening process, have them start stomping it down, then ask how long they think they'll have to stomp before the sand turns into sandstone.

3) Review the sandstone rock cycle by having each student complete the **Traveling Through the Sandstone Rock Cycle** sheet, predicting and drawing his rock's journey through the cycle.

EVALUATION

Tell students to pretend they have been hired as consulting geologists. Have each write a prediction about the future of the La Sal Mountains, and the changes the mountains will go through in the next few million years.

STATION 5


Heat, Pressure and Time
TRAVELING THROUGH THE SANDSTONE ROCK CYCLE
Moving and Building Up (Deposition)
Erosion

Objectives

Students will be able to:
- Explain why earthquakes are most common along plate boundaries.
- Explain how plate tectonics creates new igneous and metamorphic rocks.

Materials

- **Earthquake Data**
- World map with latitude and longitude lines, cut into sections corresponding to the sets of data, and laminated
- Erasable markers
- Cloth for erasing
- Masking tape
- Apple
- Phone books
- World map showing boundaries of tectonic plates

Time

- 45 minutes

POST-TRIP

POST-TRIP ACTIVITY

Plates on the go

Adapted from Geology: The Active Earth 1988, 11-12.

PROCEDURE

1) Review the rock cycle, incorporating concepts and experiences from the field trip into the discussion. Explain that students learned about erosion and deposition of sedimentary rocks on the field trip, while in this activity they will learn about the forces in the earth that cause much of the pressure and melting that can lead to the formation of new igneous and metamorphic rocks.

2) Discuss earthquakes, incorporating what an earthquake is, how long earthquakes normally last, earthquake magnitude, and how scientists measure an earthquake's magnitude. Be sure that students know that earthquakes are caused by the movement of rock along fractures, or faults, in the earth. Tell the students they will be mapping all the earthquakes of magnitude 6.5 or greater that occurred during 1997, 1998, and 1999, on a world map. Review longitude and latitude and plot one or two earthquakes on the map to demonstrate. Inform students that you've divided the Earthquake Data and maps into seven sections, and divide them into seven groups. Give each group one map section, corresponding earthquake data, a marker, and a cloth for erasing.

3) When groups finish, have them tape the map sections together in a visible place. Discuss the earthquake patterns, particularly the lines or curves that the earthquakes delineate. Review or introduce the layers of the earth, or at least the idea that there are several layers. Discuss the lithosphere and plate tectonics. Demonstrate how thin the lithosphere is by cutting an apple in half and telling them that if the apple were the earth, the lithosphere would be thinner than the apple's skin.

4) Describe what happens to the rocks at the different types of plate boundaries, using phone books to illustrate, and relating the forces created to the forces that drive the rock cycle. Reiterate that almost all faulting and earthquakes are caused by the forces at plate boundaries, so that's where almost all earthquakes occur. Tell them that we only plotted large earthquakes over a three-year period; if we had plotted small earthquakes too, and over a longer period of time, we would have seen an even clearer outline of the plate boundaries.

5) Post or pass out copies of a world map showing boundaries of tectonic plates. Discuss meanings of the different arrows and symbols on the map. Discuss where new metamorphic and igneous rocks might be created on the map.

EARTHQUAKE DATA (1997-1999)

From National Earthquake Information Center

DATA SET 1

0-5S, 0-14N; 100-180E

Latitude	Longitude
8N	128E
4S	144E
1N	123E
5S	148E
4S	129E
5S	152E
3S	142E
3S	139E
5N	127E
1N	126E
2S	125E
1N	126E
4S	153E
5N	122E
5S	151E
4S	152E
5S	153E
0	120E

DATA SET 2

16-90S; 0-99E, 0-179W

Latitude	Longitude
22S	66W
43S	43E
32S	179W
36S	108W
30S	72W
42S	80E
29S	178W
22S	177W
31S	71W
31S	71W
16S	179W
16S	179W
24S	70W
18S	179W
40S	75W
22S	179W
18S	65W
30S	179W
29S	71W
22S	176W
21S	176W
30S	178W
19S	69W

DATA SET 3

6-90S; 100-180E

Latitude	Longitude
6S	147E
13S	167E
20S	169E
32S	179E
16S	124E
27S	178E
15S	167E
22S	171E
50S	163E
63S	150E
11S	166E
8S	112E
7S	129E
7S	129E
13S	167E
6S	150E
6S	149E
6S	149E
16S	168E
7S	106E
11S	165E

DATA SET 4

15-90N; 0-49E, 0-179W

Latitude	Longitude
18N	103W
19N	107W
51N	179W
16N	98W
36N	22E
38N	21E
53N	34W
80N	2E
37N	35E
39N	29W
53N	169W
52N	178W
18N	97W
16N	88W
41N	30E
16N	97W
35N	116W
41N	31E
57N	154W

DATA SET 5

0-15S, 0-14N; 0-99E, 0-179W

Latitude	Longitude
11N	61W
11N	63W
15S	179W
15S	176W
4N	76W
4S	77W
14S	69W
14N	91W
1S	99E
8S	74W
12S	68E
1S	80W
12N	88W
15S	179W
6N	83W
9N	84W
1S	89E

DATA SET 6

15-90N; 50-135E

Latitude	Longitude
38N	57E
30N	68E
34N	60E
35N	87E
30N	58E
22N	125E
37N	70E
23N	126E
28N	57E
31N	79E
44N	130E
24N	121E
16N	120E

DATA SET 7

15-90N; 135-180E

Latitude	Longitude
44N	149E
51N	179E
55N	162E
54N	162E
54N	162E
52N	179E
24N	142E
53N	160E
29N	139E
52N	159E

References and Resources

Baars, Donald L. 1993. *Canyonlands Country: Geology of Canyonlands and Arches National Parks*. Salt Lake City, UT: University of Utah Press.

Brady, Irene. 1998. *The Redrock Canyon Explorer*. Talent, OR: Nature Works.

Chesterman, C.W. 1978. *The Audubon Society Field Guide to North American Rocks and Minerals*. New York, NY: Alfred Knopf.

Cuff, Kevin. 1995. *Stories in Stone: Teacher's Guide, Grades 4-9*. GEMS Series. Berkeley, CA: Lawrence Hall of Science, University of California.

Doelling, Hellmut H. 1985. *Geology of Arches National Park*. Utah Geological and Mineral Survey Map 74, and accompanying booklet, 15 p.

Fluegelman, Andrew, ed. 1976. *The New Games Book*. Garden City, NY: Headlands Press, Doubleday.

Geology: *The Active Earth*. 1988. Ranger Rick's NatureScope 3, no. 2. Washington, DC: National Wildlife Federation.

National Earthquake Information Center. 2000. Earthquake Data Base. In *United States Geological Survey* [online]. [cited 1 February 2000]. Available from the World Wide Web: <http://wwwneic.cr.usgs.gov>.

Rhodes, F.H., H.S. Zim, & P.R. Shaffer. 1962. *Fossils: A Guide to Prehistoric Life*. Golden Guide. New York, NY: Golden Press.

Stevens, Dale J., and J. Edward McCarrick. 1988. *The Arches of Arches National Park, A Comprehensive Study*. Orem, Utah: Mainstay Publishing.

Thompson, Ida. *The Audubon Society Field Guide to North American Fossils*. New York, NY: Alfred Knopf.

Williams, David. 2000. *A Naturalist's Guide to Canyon Country*. Illustrated by Gloria Brown. Helena, MT: Falcon Publishing.

Natural Resources

JESSICA HINES

Outline

Theme
Our national parks play an important role in the long-term monitoring of our natural resources.

Utah State Science Core Curriculum
Topic: Natural Resources
Standard [3050-02]
Students will be able to:
- Evaluate conservation practices in relation to natural resources.
- Analyze conservation practices and pollution problems.
- Accept the reponsibility to become aware of ecological and social issues related to natural resources.

Suggested Field Trip Locations
Island in the Sky District of Canyonlands National Park or another quiet area with spectacular views. For Station #1, you'll need plenty of plants for students to wash without impacting cryptobiotic soils.

Background

Clean air is a common, often underappreciated resource of the public lands of the Colorado Plateau. The Clean Air Act names 160 federal lands with pristine air quality, and mandates that air quality at these sites be monitored, preserved and enhanced. Sixteen of these sites are on the Colorado Plateau; one of these is in the Island in the Sky District of Canyonlands National Park. The equipment there measures fine particulate, acid rain and ozone levels.

Green River Overlook at the Island in the Sky District of Canyonlands National Park.

Nature plays a role in combating air pollution. Tree and plant foliage intercepts and captures large amounts of particulate dust in the air. Plants also filter gaseous pollutants. This ability to filter pollutants is one direct economic benefit of plants.

Pollutants in the air can cause acid rain or ozone imbalances. These can damage leaves, slow down plant growth, make plants more susceptible to disease and pests, and result in unhealthy or dead plants. Foliage injury has been documented at a number of national parks. Some organisms are sensitive to particular pollutants and can be used as bioindicators, or "nature's meters." Lichens and cryptobiotic soil are sensitive to the sulfur dioxide in acid rain. Milkweed is sensitive to ozone and has been used as a bioindicator of high ozone levels.

Some fine particles, or particulates, are always present in the air. The number of particulates varies; high numbers result in the visible part of air pollution. Particulate sources can be natural or human-caused, and include dust and sand from roads, fields and windstorms; smoke from burning leaves, forest fires, and wood-burning stoves; and exhaust from cars and industries. Particulates remain in the air until gravity slowly filters them out.

Ozone is an invisible gas that is a form of oxygen. It plays a complex role in the air pollution picture. High levels of it in the lower atmosphere can cause human health problems and can contribute to the greenhouse effect. Car exhaust is a major contributor of ozone to the lower atmosphere. However, ozone plays a positive role in the upper atmosphere. The upper atmosphere ozone layer blocks much of the UV sunlight from reaching the earth's surface. Normal quantities of UV light are good for such things as plant growth and suntans. But the increase in UV light that would result from a damaged ozone layer would lead to increased incidences of skin and eye diseases in humans, and damage to some wildlife and plants.

The single largest factor in the destruction of the ozone layer is a family of chemicals called chlorofluorocarbons (CFCs). These were used in manufacturing hundreds of different products, including styrofoam packaging, aerosol spray cans, and the coolants in refrigerators and air conditioners. Their use has been outlawed in the United States and many countries. But even when all countries quit using CFCs, they will linger in the upper atmosphere for decades. At Canyonlands National Park, ozone is monitored at ground level. UV light is also monitored, which indirectly reflects the condition of the upper atmosphere ozone layer. Scientists monitor ozone levels in order to study trends in national parks as well as global trends.

Noise, in the form of traffic, horns, sirens, dogs, jackhammers, and overhead jets, is a type of pollutant. National parks and other lands located in remote, untrafficked areas remind people how noisy their everyday worlds are and how precious silence is. Besides the obvious stress factor, other specific effects of noise on human beings have been well documented. Long-term exposure to high levels of noise decreases hearing ability, increases the level of cholesterol in the blood, and raises blood pressure. The southeastern Utah national parks monitor noise pollution to establish baseline scientific data for future use.

PRE-TRIP ACTIVITY

The air we breathe

PROCEDURE

1) Tell students where they will be going on their upcoming field trip. Explain that the field trip topic is a natural resource: *air*. Have students blow into their hands. Ask them to describe some properties of air, such as *invisible* and *tasteless*, and list them on the board.

2) As a way of "seeing" the "invisible" air, have three students each blow up a balloon. Have them let the air out slowly. Could the class hear the air escape? Ask them to each blow just one large breath into the balloons and hold the ends closed. Compare sizes (to see who has the most "hot air"). Count or guess how many normal breaths would fill a balloon, and write the number on the board. Have the three volunteers return to their seats. Next have students breathe normally and count how many breaths they take in one minute. Based on this, calculate how many breaths the whole class takes in one minute, and how many balloons this would fill.

3) Based on 20 breaths per minute, calculate how many breaths one person would take in a year. You may have different volunteer students work out each multiplication step on the blackboard: 20 breaths/min. X 60 min./hour X 24 hours/day X 365 days/year = 10,512,000 breaths/year

Conclude that because we breathe so much air continuously throughout our lives, clean air is important. Breathing dirty air over time may damage our lungs and cause disease.

4) Ask students if they think the air in their classroom is pretty clean. Do they think there are any particles in it? Explain that they will start an investigation today to address this question, and finish it during the post-trip visit after the field trip. Distribute an index card to each student. Have them put their names on the cards, and predict three "items" they might find on their card at the end of the experiment. Then have students smear a small amount of petroleum jelly on the other side of their cards. Tell them that the jelly will catch any particles in the air, and instruct them to pick out-of-the-way places in the room to put their cards.

5) Discuss that air is generally dirtiest in cities, industrial areas, and valleys, and that it tends to be cleaner in national parks and remote areas. But emphasize that wood-burning stoves and cars in small towns, and pollutants from far-away industries and cities, can affect the air even in remote areas, as can windstorms and forest fires. Tell students that the Clean Air Act defines different classes of air. Those places with the cleanest class of air, such as Canyonlands National Park, are required by the Act to monitor air pollution.

6) Review the items that students need to bring to school on the day of the field trip.

Objectives

Students will be able to:
- List two properties of air.
- Identify one reason that clean air is important.

Materials

- 3 balloons per class
- Index cards
- Petroleum jelly
- A few tongue depressors

Time

- 30 minutes

PRE-TRIP

Objectives

Students will be able to:
- Name at least one way that plants clean up the air.
- List two economic benefits of plants.

Materials

- Dust mop
- 4 plastic funnels
- Paper coffee filters
- Water spray bottles
- Extra water
- Hand lenses
- (optional) Contrasting photos of a city on a clean air day and a bad air day

Time

- 30 minutes

STATION ONE

Nature's public services: dust mops

Adapted from National Park Service and others 1989, 4-9

NOTE

The location of this leaf-cleaning activity will need to change as the station is repeated if the students effectively clean the leaves in a given area.

PROCEDURE

1) Briefly discuss views and clean air as one of the natural resources that brings visitors to southeastern Utah. Explain that air quality monitoring stations such as the one at Island in the Sky in Canyonlands National Park use a series of filters to filter particulates out of the air. Find out if students are familiar with the brown air sometimes seen in Salt Lake City or even the Moab Valley in winter. (Optional: Show photographs.) Explain that when there are a lot of particulates, the air looks brown.

2) Show students the dust mop and explain how it picks up and gathers dust from the floor. Shake it to demonstrate that it is holding dust. Explain that plants filter dust from the air in a similar way. Ask students if they think the plants around them are holding dust. Tell them that they will be experimenting to answer this question. Have students gather closely and pull out of your backpack a spray bottle of water, plastic funnel and paper coffee filter. Ask how these items might be used to answer our question.

3) Put students in pairs, and give each pair a water bottle, funnel, and filter. Instruct one student to pour water over some low-hanging leaves into the funnel filter held by the other student. Have students find the “cleanest” and “dirtiest” plants within a designated area, including a roadside area if possible. Examine the particulant content on their filters using hand lenses. Have student pairs compare findings.

EVALUATION

Have students report their findings to the rest of the group and state whether they think a particular plant is a good cleaner or not.

STATION 1

STATION TWO

What's in the rain?

PROCEDURE

1) Define acidity, and discuss briefly the reasons for monitoring acid rain, including the effects of acid rain on plants, animals and rocks. Explain that rain is usually slightly acidic, but that it can cause problems if it becomes more acidic. Tell students that Canyonlands National Park has an Acid Rain Monitoring Station. It collects precipitation, which is analyzed in a lab to determine its pH (acidity or alkalinity), conductivity, and the concentration of several elements and compounds. Explain that the results of the analyses are entered into a computer program where they can be mapped and compared with results of approximately 200 acid rain monitoring sites in the country.

2) Explain that baking soda is an example of a substance that is alkaline, the opposite of acidic. Pair students. Instruct them to do an experiment starting with the question, *Which liquid reacts the most with baking soda?* Distribute a copy of the **Science Investigation Form** to each pair and have them write down their hypothses. Explain the procedure, giving students time to write down the steps:

1. Using litmus paper, measure the pH of all three liquids and record.
2. Mix each liquid with baking soda. Record a description of each reaction.
3. Using litmus paper, measure the pH of all three mixtures and record.

Distribute a set of three bottles, eyedroppers, some baking soda, three small dishes, stirring stick and some litmus paper to each pair. Have them carry out the procedure and record results. Ask them to dump solutions into waste container when finished.

3) As a group, ask each pair for their results (the answer to the original question). Did all pairs have a similar result? Ask if they can think of any conclusions from their experiment. For example, did the fastest and/or most vigorous reactions correspond to the most acidic liquids? Look at the pH values of other substances (shown in the right margin of the **Science Investigation Form**) and compare them to those of the measured liquids and baking soda. Discuss conclusions.

4) Review and discuss further effects of acid rain on buildings, rocks, plants, animals and people. Discuss remedies, large-scale or small-scale, for the acid rain problem.

OBJECTIVES

Students will be able to:

- Measure and record pH of several liquids, using litmus paper.
- Follow procedural steps of a scientific inquiry.
- Describe two ways that acid rain affects rocks, plants, animals, and/or people.

MATERIALS

- **Science Investigation Form**
- 3 sets of 3 small bottles of lemon juice, cola, and distilled water
- Eyedroppers
- Baking soda
- Small dishes
- Stirring sticks
- Litmus paper for testing pH of liquids
- Large container to hold used liquids

TIME

- 30 minutes

STATION 2

SCIENCE INVESTIGATION FORM

What's in the rain?

Scientists' Names: ______________________________ Date: ____________

QUESTION

Which liquid reacts the most with baking soda?

PREDICTION OR HYPOTHESIS

PROCEDURE

List step by step.

1.

2.

3.

RESULTS

What actually happened? Which liquid reacted the most?

CONCLUSIONS

What did we learn or what do our results mean?

pH Values

Substance	pH	
	14	BASIC
Household Bleach	13	
Ammonia	12	
	11	
	10	
Baking Soda	9	
Sea Water, Egg Whites	8	NEUTRAL
Human Blood, Tears, Saliva	7	
	6	
	5	
Tomato Juice	4	ACID
Cola	3	
Lemon Juice	2	
Gastric Juices	1	
	0	

STATION THREE

Noises off!

PROCEDURE

1) Walk towards overlook or other quiet spot. If there is a drop-off, gather students and address expected behavior before you reach the edge. At the quiet spot, discuss sounds and noise, and the difference between the two. Describe sound as an invisible wave that travels quickly through the air, but not as quickly as light. If appropriate, allow each student to yell or make one loud noise into the canyon below, and listen to the echoes. Discuss effects of noise on people and wildlife. Tell students that because of these negative effects, the quiet of remote areas is considered a natural resource.

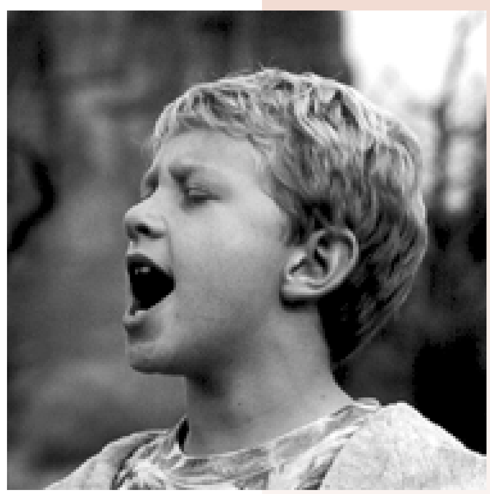
2) Tell students that they will be finding a spot by themselves, sitting quietly and listening, and drawing a map of the "symphony of sounds" around them. Instruct them to place themselves in the middle of their map, and draw pictures of the sounds they hear around them on the map. Show students a sample sound map. Help students find spots within your view.

3) Gather students. Ask if they heard more sounds when they were alone and listening for them. Have students take turns sharing their maps and what they heard. Review the idea that both clean air and quiet are natural resources worth protecting, and that dirty air and noise have negative effects on both people and wildlife.

4) Play Sound Charades. Students take turns choosing a sound charade card and acting out the sound on the card, without talking. Others try to guess what the sound is.

EXTENSION

Have students dramatize reactions to loud noises, surprise noises, quietness and other specific noises.



Objectives

Students will be able to:
- Realize that remote areas can provide a break from the noises of town, cars and people.
- Name at least two ways noise pollution affects humans and wildlife.

Materials

- Paper and pencils
- Clipboards
- Sample sound map
- Sound Charade cards (Label each card with a sound or noise, such as bird song, traffic or fire engines)

Time

- 30 minutes

STATION 3

Objectives

Students will be able to:
- Explain why upper atmosphere ozone is beneficial, and name one source of depletion.
- Cite one reason ozone and other pollutants are detrimental in the lower atmosphere.

Materials

- Clipboard with paper and marker
- **Ozone Depletion** (enlarged to poster size)
- Aerosol spray can
- A dozen index cards (label one *CFC*, and the others *ozone*)

Time

- 30 minutes

STATION FOUR

No zone for ozone

PROCEDURE

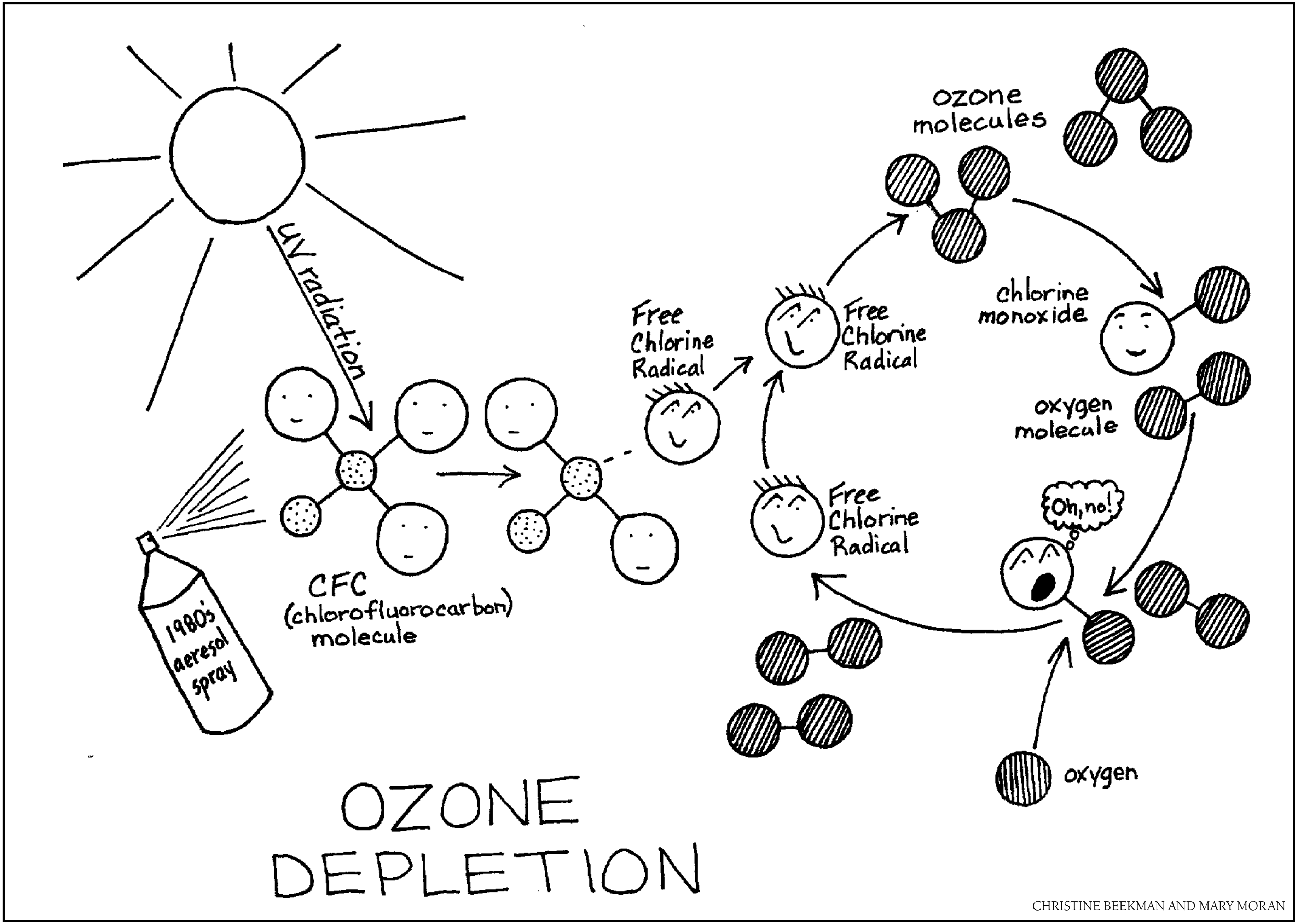
1) Explore student knowledge of the greenhouse effect, global warming, and the ozone layer. On the paper and clipboard, draw the lower atmosphere "blanket" around the Earth. Explain that polluting gases can make the blanket too heavy, holding in too many solar rays and causing the greenhouse effect. Add that many of these gases are also bad to breathe. Describe ozone as one of the gases that is harmful if there's too much of it in the lower atmosphere layer. Explain that ozone is not what makes the air look dirty; it is invisible and odorless. Inform students that ozone concentrations in the lower atmosphere are affected by weather conditions. Draw the upper atmosphere ozone layer and discuss the benefit of ozone here, in blocking some of the sun's ultraviolet (UV) rays. Show and discuss the **Ozone Depletion** poster, holes in the ozone, and CFCs.

2) Play Ozone Depletion Tag with as many students, teachers and parents as you can round up. Review that ozone is good in the upper atmosphere and why, and that CFCs destroy this ozone. Define boundaries and have each participant pick and secretly look at one card to determine what type of gas they will be in the upper atmosphere. Have participants return their cards and inform them that one of them is a CFC while the rest are ozone. Ask students to spread out, floating in the upper atmosphere. Instruct them that when you say "go," the CFC should tag ozones, destroying them. Explain that after an ozone is tagged, it should act as a free radical chlorine, and tag other ozones. It doesn't take long until all of the ozone is gone. Play two or three rounds.

3) Play Silent Killer to reinforce the concept and hidden nature of ozone depletion (adapted from Fluegelman 1981, 81). Have players sit in a circle; distribute and recollect the cards as in the previous game. Instruct the unknown CFC to wink at an ozone when no one else is looking. Instruct any ozone that is winked at to *quietly* pause a few seconds, then say, "I've been destroyed." All live ozones should watch carefully and try to identify the CFC killer (but each one only gets one guess).

4) Using the aerosol spray can as a prop, explain that the U.S. and many countries have done much to reduce CFCs, though some countries still use them. Explain that ozone is monitored both at ground level and indirectly, in the upper atmosphere, at the air quality monitoring station at Island in the Sky. Discuss individual ways of reducing ozone in the lower atmosphere.

STATION 4


uv radiation
1980's aeresol spray
CFC (chlorofluorocarbon) molecule
Free Chlorine Radical
Free Chlorine Radical
Free Chlorine Radical
ozone molecules
chlorine monoxide
oxygen molecule
Oh, no!
oxygen
OZONE DEPLETION
CHRISTINE BEEKMAN AND MARY MORAN

Objectives

Students will be able to:
- Name two airborne pollutants in the classroom.
- List three reasons why clean air is critical.
- Identify one national park role in preserving clean air.

Materials

- Copies of **Classroom Air Pollution**
- Hand lenses
- Rulers

Time

- 30 minutes

POST-TRIP

POST-TRIP ACTIVITY

Is there a pollution solution?

PROCEDURE

1) Review the main concept of each field trip station. Review reasons that clean air is important.

2) Pass out a **Classroom Air Pollution** sheet and ruler to each student, and read over the sheet. Draw an example on the blackboard to show students how to write measurements next to drawings of larger particulants, and specify what measurement units they should use. Ask students to retrieve the petroleum jelly collector cards from the Pre-Trip Activity, examine them with hand lenses, and complete the sheets.

3) On the board, record some of the results of student observations of their air pollution collection cards. Ask which findings students found most surprising. Ask if students can come up with any conclusions from this investigation. Emphasize that this investigation is in many ways similar to the scientific high-tech monitoring facility at many national parks, in that the classroom monitoring took place over a long period of time, students could quantify the particulates found, and they have described them and measured their length. Reiterate that in many ways this is exactly the type of work scientists do to monitor pollution. Ask students what other investigations or experiments they could do to study air pollution, in the classroom or elsewhere.

EXTENSIONS

Have students research more about the Clean Air Act and the long-term monitoring efforts in many national park units, and write letters to congresspeople with their opinions on these.

Have students design a long-term school air-quality monitoring program, including choosing sites and materials needed, and designing data sheets.

CLASSROOM AIR POLLUTION

1. Look closely at your card with a hand lens. What do you see? Sketch four particles that are on your card in the boxes below. Measure at least two of the largest ones, and write the measurements next to the drawings.

2. Ask your classmates what they found on their cards. What was the most common item found on the cards?

____

3. If there is air pollution in your classroom, list some ways you could help reduce the problem:

References and Resources

Fluegelman, Andrew. 1981. *More New Games!...and Playful Ideas from the New Games Foundation.* Tiburon, CA: Headlands Press.

Levine, Joel S. 1992. Ozone, climate, and global atmospheric change. Reprint from *Science Activities* 29, no. 1: 10-16. Washington, DC: Heldref Publications.

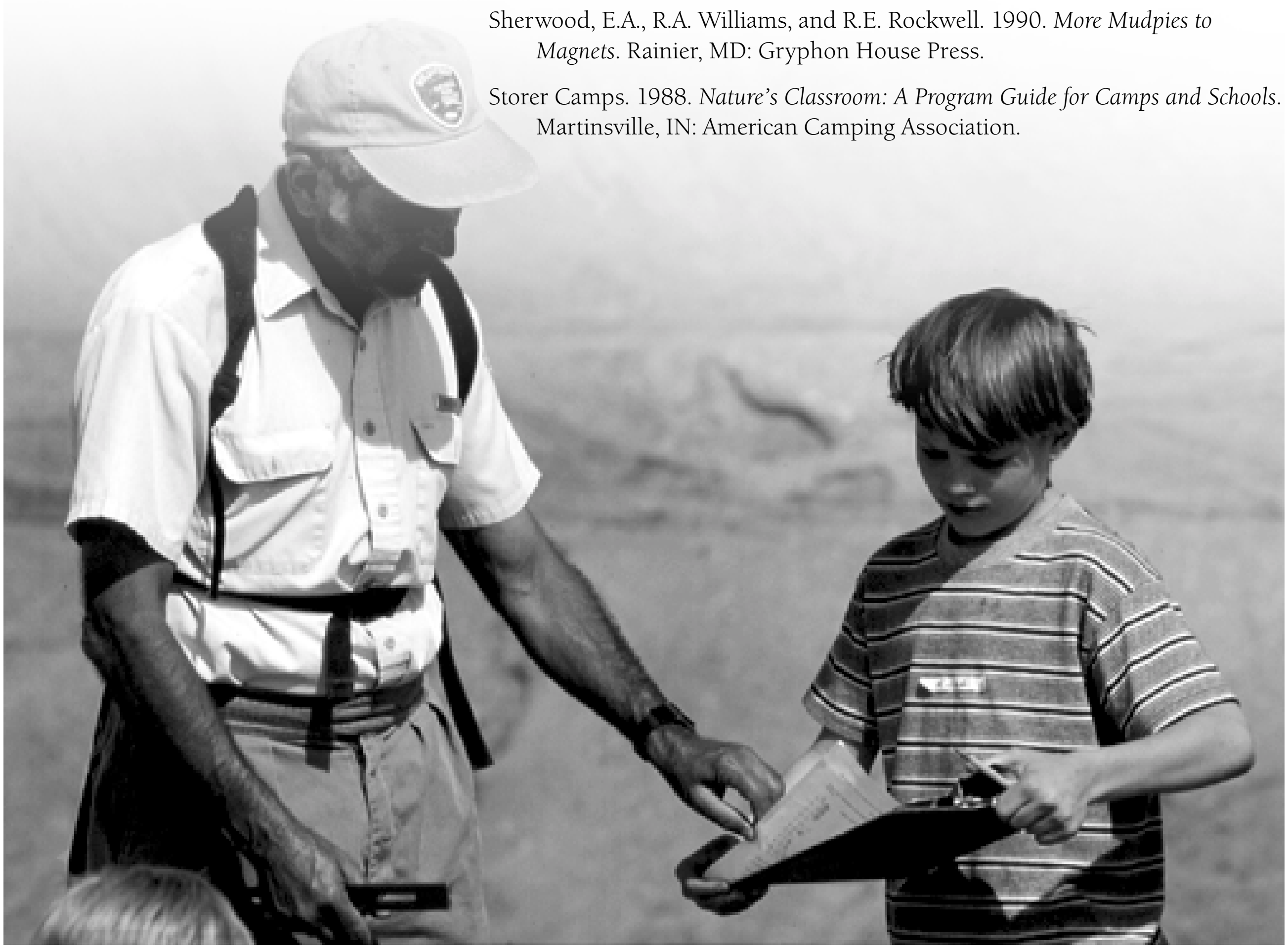
National Park Service and National Biological Survey Colorado Plateau Research Station at Northern Arizona University. 1994. *Where the Earth is the Floor of the Sky: Visibility on the Colorado Plateau*. Brochure. U.S. Government Printing Office. <www2.nature.nps.gov/ard/parks/colplat.htm>

National Park Service, Minnesota Environmental Education Board, and the National Parks and Conservation Association. 1989. *Biological Diversity Makes a World of Difference*. Washington, DC: National Parks and Conservation Association.

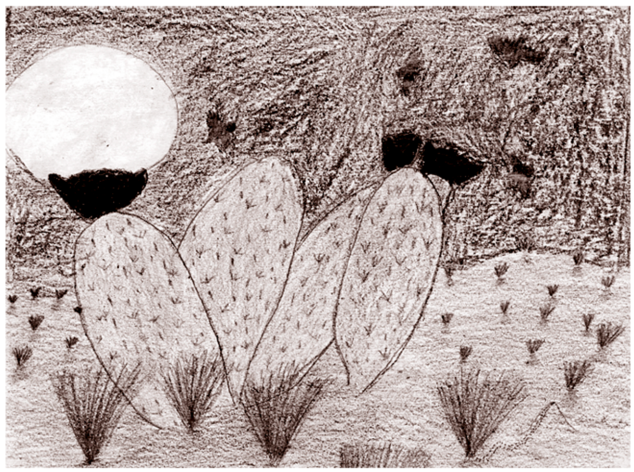
Peterson, M.F. 1973. *Activities for Environmental Education: Water, Air, Soil.* Bismark, ND: Department of Public Instruction.

Sherwood, E.A., R.A. Williams, and R.E. Rockwell. 1990. *More Mudpies to Magnets*. Rainier, MD: Gryphon House Press.

Storer Camps. 1988. *Nature's Classroom: A Program Guide for Camps and Schools*. Martinsville, IN: American Camping Association.



Plant Adaptations



TESSIE GRAHAM

Outline

Theme
Plants that live in the high desert climate have various adaptations to survive and thrive.

Topic
Plant Adaptations

Suggested Field Trip Locations
This field trip was designed for Upper Courthouse Wash, 1/4 mile above the bridge in Arches National Park. Other suitable locations would have both riparian and desert zones, with a diversity of plants. Because many materials are specific to particular plants, some may need to be altered to fit a different location's plants. For the most overlap in plants, choose a site with an elevation as near 4100 feet as possible.

Background

Desert plants are adapted to their arid environment in many different ways. Stomata are the holes in plant leaves through which they transpire water. Many desert plants have very small stomata and fewer stomata than those of other plants. The stomata of many cacti lie deep in the plants' tissues, which reduces water loss by keeping the hot, dry wind from blowing directly across the stomata.

The leaves and stems of many desert plants have a thick, waxy covering. This waxy substance does not cover the stomata, but it covers most of the leaf area, so it keeps the plants cooler and thus reduces evaporative loss.

Small leaves on desert plants also help reduce moisture loss during transpiration. Small leaves mean less evaporative surface per leaf. In addition, a small leaf in the sun doesn't reach as high a temperature as a large leaf in the sun.

Some plants, such as Mormon tea and cacti, carry out most or all of their photosynthesis in their green stems. (Cactus pads are stems, botanically speaking.) Some desert plants grow leaves during the rainy season, then shed them when it becomes dry again. These plants, including blackbrush, photosynthesize in their leaves during wet periods. When drought sets in and the plants lose their leaves, some of these plants can photosynthesize in their stems. Others cut down on water loss even further by temporarily shutting down photosynthesis.

Other desert adaptations shared by a number of plants include shallow widespread roots to absorb a maximum of rainfall moisture, and spines or hairs which shade plants and break up drying winds across the leaf surface.

Other specific desert plant adaptations

Cacti - Cactus pads are modified stems with a waxy coating. Their root system is very shallow, drinking up ephemeral rainwater. Small rain roots can grow as soon as soil is moistened by rain, and later dry up. Prickly spines are modified leaves that break up the evaporative winds blowing across pad surfaces, and can help shade the stem. Cacti utilize CAM photosynthesis, in which stomata open only at night when the plant is relatively cool, so less moisture is lost through transpiration. But more passes through a plant's stomata than moisture. Gases, including carbon dioxide going in and oxygen going out, pass through the stomata. This gas exchange is part of the process of photosynthesis. But photosynthesis also requires sunlight. The CAM process includes a way of chemically storing the carbon dioxide until the sun comes out, when it can be used to complete the photosynthetic process. (A stoma is like a window; it has to be open to let air and water in or out, but sunlight can come in even if it's closed.)

Desert Annuals - These avoid drought and heat by surviving as long-lived seeds stored in the soil, sometimes for decades. The seeds have adaptations assuring that they germinate and grow during wet periods.

Evening Primrose - Thickened taproots store water and food.

Globemallow - These are covered with dense, star-shaped grayish hairs that reflect sunlight and break up the wind.

Juniper - Leaves are reduced to tiny, waxy scales that cover the twigs and small branches. Fruits are also covered with a waxy coating. Junipers have the ability to cut off water to a major branch during a drought, resulting in a dead branch but a live tree.

Sego Lily - It can lie dormant as a bulb during the driest years.

Paintbrush - They are partial parasites. Their roots tap into nearby plant roots, usually sagebrush or grasses, to suck food and moisture from their host.

Piñon Pine - They depend on enormous root systems. Piñon taproots stretch down 40 feet or more in deep soils; in shallow soils, lateral roots stretch outward the same distance.

Sagebrush - Hairy leaves insulate this plant against heat, cold, and dry winds. Retaining its leaves year-round allows the plant to produce food most of the year. Sagebrush has adaptations to cold winters; it can photosynthesize when temperatures are near freezing, and its leaves point in all directions, allowing them to catch sunlight from many different angles.

Some desert plants take advantage of the nights' cooler temperatures to become "active." Some evening-blooming plants in the desert include evening primrose, sacred datura, sand verbena, and yucca. Cacti also take advantage of cooler nights. Cacti stomata are open mostly during the nighttime. Therefore the plant can transpire, or lose water, during a time when it is likely to lose the least amount of it. The rest of the cacti photosynthesis process takes place during the daylight hours.

Desert animals also take advantage of nighttime's cool refuge. Without light for visual cues, desert animals rely on their other senses to help them navigate. Nectar-eating bats use echolocation to identify evening blooming plants. Echolocation works similar to radar; the bat sends out a call, then receives the waves that are reflected back. The reflection indicates the direction and distance of the reflecting object.

The yucca and the yucca moth have a fascinating nighttime association. After mating, the female moth gathers pollen from one yucca flower, packs it into a ball, and then flies into the night, locating other yucca flowers primarily by "smelling" with her antenna. She visits several flowers, each time laying some eggs in the base of the pistil and packing some of the pollen from her pollen ball down the pistil for her young to feed on. Thus she fertilizes the yucca flowers. Yucca flowers are only pollinated by yucca moths, and yucca moth young only feed on yucca pollen.

PRE-TRIP ACTIVITY

What's my adaptation?

PROCEDURE

1) Have students hold their thumbs against their palms, then untie and tie their shoes, or if they don't have laces, write their name on a sheet of paper. After a few minutes, re-focus them, and ask if these tasks were difficult. Explain that thumbs are an adaptation that help us do many things, and that all animals have body parts and other physical adaptations that help them to survive. On our field trip, we will look at the physical adaptations that plants have for survival.

2) Ask for a volunteer to stand. Point out and relate human physical parts to plant parts: Feet are roots; legs and torso are stem, arms are branches, hands are leaves, and head is flower or seed head. Explain that plant adaptations are physical ones, and give examples such as extra long roots to reach deep water; hairy, gray leaves to shade leaf surfaces and break up the wind in sunny, windy areas; and light, fluffy cottonwood seeds to disperse in the wind. Plants have many physical adaptations, but they do not have behavioral adaptations like animals. Discuss with students what it means to adapt. Stress that humans or other animals can sometimes adapt behaviorally to new situations, but physical adaptations and most behavioral ones evolve too slowly for this. Discuss the conditions a plant or animal around Moab would have to be adapted to, including lack of water, hot summertime temperatures, cold winter nights, and wind.

3) Have students close their eyes to begin the What's My Adaptation? game (adapted from Cornell 1979, 69). Hang a name tag around each student's neck, with the tag on her back. Instruct students to open their eyes, but not to look at their own tags. Show them a sample name tag, and tell them that each has a picture of either a plant or animal from our area. Instruct them to walk around the room and ask each other questions that can be answered by yes or no, each trying to figure out what organism is on their back. A student may ask another student up to three questions before moving on to someone else. Go over some examples of good questions together before the students get up from their seats. As students figure out their creatures, they should sit down, turn their name tag over, and read the creature's adaptation written on the back of the tag. When all are seated, ask for volunteers to share their identities and read their adaptations. Review the items that students need to bring to school on the day of their field trip.


NATIONAL PARK SERVICE/TOM GRAY

OBJECTIVES

Students will be able to:

- Describe or give an example of an adaptation.
- Name two environmental characteristics to which an organism may be adapted.

MATERIALS

- 30 name tags, each with a picture of a plant or animal, and an adaptation described on the back. (For examples, see 4th Grade: Utah Animal Life Post-Trip.)

TIME

- 30 minutes

PRE-TRIP

Objectives

Students will be able to:

- Name three desert plant adaptations.
- List two factors that make life in the desert challenging for plants.

Materials

- Clue Cards (Write these to describe the location of the Mystery Trail plants and their adaptation cards/ objects. Have a couple of the clues instruct students to run to the next plant, if safety allows.)
- **Adaptation Cards**
- Adaptation Objects (See object information on Adaptation Card page.)
- Two pictures of each plant in the Mystery Trail, on index cards, for the Desert Plant Adaptation Relay.

Time

- 30 minutes

STATION ONE

Desert plant mystery trail

NOTE

Adaptation Objects and **Adaptation Cards** must be set up in advance.

PROCEDURE

1) Have students list what plants need to survive, and be sure that they include water, soil and sunlight. Discuss characteristics of the desert that make it difficult for plants to grow. It's dry, windy, hot in the summer, cold on winter nights, and there are animals that might eat the plants.

2) Tell students that they will be following clues to discover specific adaptations that plants have to live in this environment. Ask the group to listen carefully as clues are read. Have student #1 read the first clue card. The clue will lead students to a specific individual plant. Here there will be an object hidden that gives a clue about an adaptation of that plant, along with an **Adaptation Card** explaining the connection. Ask that only student #1 pick up the object and **Adaptation Card**. Have the students guess what the adaptation is from looking at the object. Then have student #1 read the card. Briefly discuss the adaptation. Then hand student #2 the next clue card to read. Proceed until all the clues have been read, pursued, and discussed.

3) If there's time, introduce and play the Desert Plant Adaptation Relay, a review activity. Divide students into two groups, and designate a starting line for them to form two lines behind. Place plant cards together about 50 feet away. Read one of the following clues at a time:

- There is an animal nearby that eats plants. But it won't munch on you!
- It's 110°, but your leaves are adapted to keep much of your water.
- The dry wind won't evaporate your water.
- It hasn't rained in weeks, but you have stored water to use.
- The sun is bright, but your leaves reflect much of the sunlight, keeping you cooler.
- Though the soil is dry, your roots can reach moisture deep in the ground.

Give the two teams five seconds or so to discuss the answer, then give them a go signal. The first student on each team should run, pick up an appropriate card, and run back. The first student back scores a point for her team if she picked the correct card. If not, the other team gets a point, if their runner picked the correct card. There may be more than one right answer to some clues.

STATION 1

ADAPTATION OBJECTS

Cliffrose	Bag of crayons
Blackbrush	One narrow-mouthed water bottle and one broad-mouthed water bottle
Rabbitbrush	White cloth
Prickly Pear Cactus	Sponge
Sagebrush	Fuzzy cloth
Prickly Pear Cactus	Stocking cap with pipe cleaners sticking through it to look spiny
Yucca	Garden hose (or picture of one)

ADAPTATION CARDS

Cut Adaptation Cards apart along dashed lines.

The leaves of Cliffrose are like crayons because they have waxy coatings. The waxy coatings keeps moisture in the leaves. Why would this plant need to conserve moisture?	Prickly Pear Cactus is like a sponge because its pads absorb water when it rains. The cactus stores and uses the water until the next rainstorm. The pads may look fat if it's been rainy lately. They may look shriveled if it hasn't rained in a long time. Does this cactus have fat or shriveled pads?
Light colors absorb less heat than dark colors. Rabbitbrush has light-colored leaves that absorb less heat. What would a plant gain from staying cool?	Openings in leaves called stomata allow water and air to escape from the plant. In some plants, the openings are large, like the large-mouthed water bottle. In Blackbrush, the openings are small, like the water bottle with a smaller mouth. How does this adaptation help Blackbrush to survive in the desert?
The Sagebrush has fuzzy leaves like this cloth. Plants and animals dry out when water evaporates from skin or transpires from leaves. Wind on our skin or on leaves speeds up the drying. But if we wear a shirt or leaves have hairs on them, the wind is broken up. Less water is lost. Look closely at the leaf hairs.	Prickly Pear Cactus is like this hat because of its spines. Like the hairs on the Sagebrush leaves, spines break up wind and lessen evaporation. The spines also keep some animals from munching on the cactus.
Like a garden hose, a Yucca's roots move water from one place to another. A Yucca has a taproot that can grow up to 15 feet long. How does this long taproot help the plant?	

Objectives

Students will be able to:
- Find a desert plant and explain a leaf adaptation.
- Describe the steps of the scientific process.

Materials

- Hand lenses
- Small poster listing five adaptations
- Two sturdy cups
- Clipboards & pencils
- Copies of **Science Investigation Form: Are Leaves Adapted?**

Time

- 30 minutes

STATION TWO

Are leaves adapted?

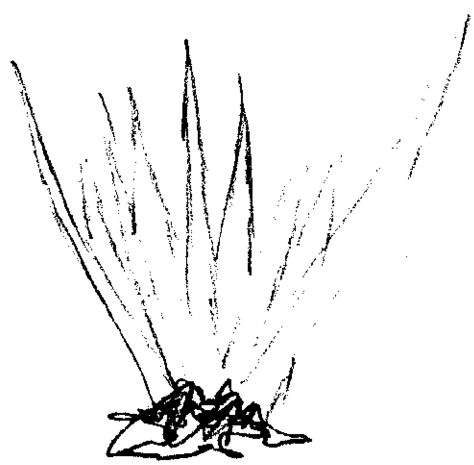
PROCEDURE

1) Review and discuss the following concepts: All life comes from the sun's energy, and this energy is gathered in leaves of plants and converted into useable plant energy. By-products of this process include oxygen and water. Loss of water is a concern for plants in the desert, so many have adaptations in their leaves to avoid losing as much water. Some of those leaf adaptations are: (1) hairy or fuzzy leaves; (2) small leaves; (3) curled-up leaves; (4) wax-coated leaves; and (5) green stems but no leaves. Display small poster listing these five adaptations, and discuss them. Define small leaves as less than one inch long.

2) Tell students they are going to work in pairs and do a scientific investigation, using the scientific process. Pass out copies of the **Science Investigation Form: Are Leaves Adapted?** and clipboards. Go over the form, discussing the steps of the scientific process. Our question for the investigation will be "If we observe eight different leaves, how many of them will have one of the adaptations that we've listed for the desert environment?" (Adjust the number of leaves as dictated by time.) Have them write the question and then their hypotheses.

3) Explain the procedure that students will follow. They will be looking at eight different types of leaves, drawing them, and describing which adaptations they see, if any. In order for the investigation to be unbiased, they need to collect the first eight different leaves that they can find, in a defined area. Descriptions may be brief. Have students write the following procedural steps on their form: (1) Find eight leaves. (2) Draw each leaf and describe its adaptation, if it has one. At this point, have students divide the back of their investigation sheet into eight squares for their drawings and descriptions. Define the study area and monitor students while they collect data.

4) Gather students. Share some of their pictures and descriptions. Ask them how many of their eight leaves had at least one of the adaptations on our list. Have them write this number down under results. Discuss why some of the leaves didn't have the adaptations. (They may be annuals with seed adaptations rather than leaf adaptations, or may have other types of adaptations.) Discuss and have them write conclusions.



JARVIS LUTHER

STATION 2

SCIENCE INVESTIGATION FORM

Are leaves adapted?

Scientists' Names: ____ **Date:** ______________

QUESTION

If we collect __ different leaves, how many of them will have at least one of the desert adaptations we have listed?

PREDICTION OR HYPOTHESIS

PROCEDURE

List step by step.

RESULTS

What actually happened?

CONCLUSIONS

What did we learn or what do our results mean?

Objectives

Students will be able to:

- Describe two environmental conditions of riparian zones that are different than the conditions in the surrounding desert.
- Name one riparian plant, and describe one of its adaptations to where it lives.

Materials

- **Student Key**
- Copies of **A Key to Common Riparian Plants of Southeastern Utah**
- **Riparian Plant Clue Cards**

Time

- 30 minutes

STATION THREE

The riparian ramble

PROCEDURE

1) Define riparian and discuss the kinds of conditions plants living near water in the desert must be adapted to (flash floods, sandy and salty soils, hot summer days, animals). Stress that these plants do not have to have the adaptations for saving water that desert plants do, because they live where there is always water at the surface or just underground. Explain that most of the wildlife in Utah is dependent on riparian areas to survive. Discuss reasons, including a few interactions of plants and animals in a riparian community.

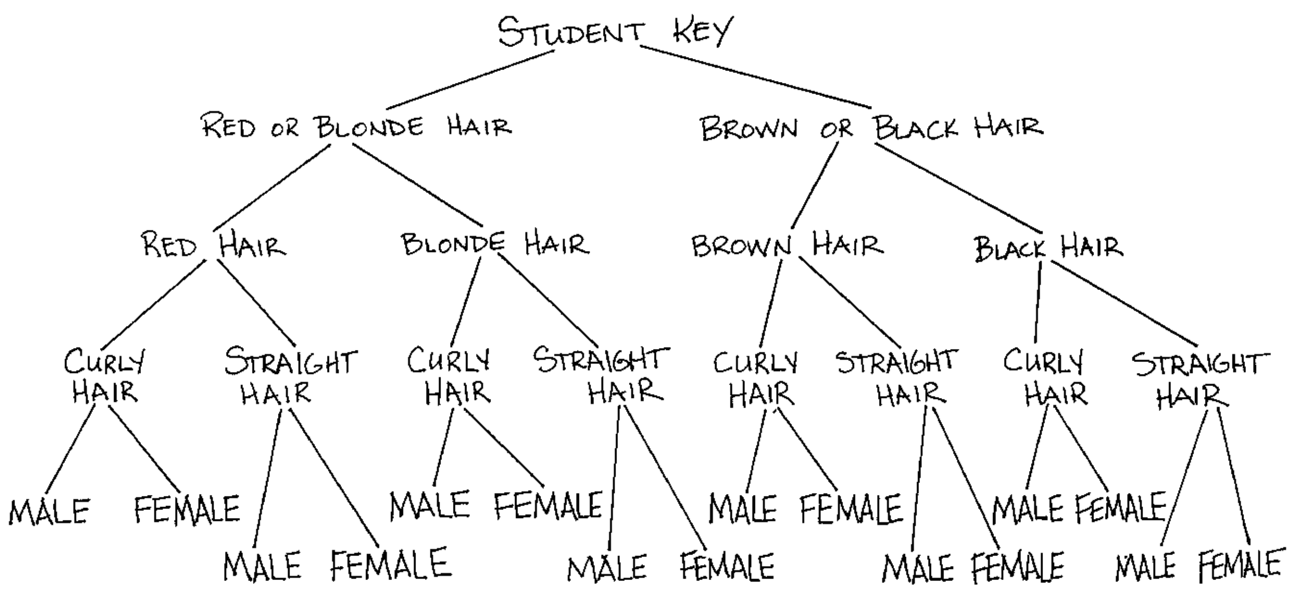
2) Tell students they will use a plant key to identify some of the riparian plants. In order to first practice using a key, have students play a game with a key to students. Ask one student to leave the group while you pick a student who is "it." Have the first student return to the group and, using the **Student Key**, ask questions to determine which student is "it." Play several times.

3) Pass out the copies of the **Riparian Plant Key**, and briefly discuss its use. Model its use by walking to the wash and going through one identification with the entire group. Define boundaries along the wash, and have students work in pairs to identify riparian plants. (Not all plants in this area are on the key; steer students to those that are.) Review findings.

4) Collect plant keys and pass out Riparian Plant Clue Cards. Each student gets at least one card, but students may work in pairs. Instruct students to look for a plant to match each clue card within specified boundaries. After a few minutes of looking, walk as one group up the wash, asking each student to stop the group when her plant is reached, and to read her card.

5) During this station, include discussion wherever appropriate on salt tolerant plants, root depth, deciduous plants and trees, perennials versus annuals, leaf shape, and plant morphology. At the end of the station, review the definition of riparian and a few conditions to which plants here must be adapted.

STATION 3



Add eye color or other distinguishing features as needed.

A KEY TO COMMON RIPARIAN PLANTS OF SOUTHEASTERN UTAH

Always shorter than a human

Triangular stem
SEDGE

Round stem

Hollow,
segmented
stem
HORSETAIL

Hollow stem with
flowers on tip or side
RUSH

Sometimes grows taller than a human

Woody stem
(Tree or shrub)

Scale-like leaves
TAMARISK

Leaves not scale-like

Leaves much longer than wide

Green leaves,
no thorns

Leaf edges smooth
or slightly toothed
WILLOW

Leaf edges toothed,
flower clusters at
tops of branches
SEEP-WILLOW

Silvery, fuzzy leaves.
Plant has thorns.
RUSSIAN OLIVE

Leaves not much longer than wide

Leaves in groups of three
BOXELDER

Leaves not
in groups

Leaves always less
than 2 inches across
WATER BIRCH

Leaves often more
than 2 inches across
COTTONWOOD

Non-woody stem
(Herb)

Round, hollow
stem with flowers
on tip or side
RUSH

Flat blade-like
leaves with big
sausage-shaped
fruits on top
CATTAIL

RIPARIAN PLANT CLUE CARDS

Cut apart along lines.

I am a deciduous plant. When the weather turns cold in the fall, I shed my leaves. Because I am a riparian plant, I have plenty of water to grow new leaves every spring.	Thick bark protects me from damage caused by insects and other animals. The bark also helps to keep me from drying out.
I grow near streams where flash floods occur frequently. Because my branches are extremely flexible and bend easily, they don't break when the water rushes over me.	I grow in washes where flash floods occur frequently. I have very narrow leaves, which are resistant to being torn off in the floods.
My thorns keep animals at a distance, so they don't chew on my stems, branches, or leaves.	I produce "hitchhiker" seeds. These seeds travel in the fur of animals (or in your socks)!
I can grow in very salty soils. Find me near crusty white salt deposits.	I grow to be a large tree with large heart-shaped leaves. I lose lots of water in transpiration through my leaves, so I only grow where water is flowing or just under the surface of the ground.

STATION FOUR

In the cool of the night

PROCEDURE

1) Ask students to quietly think back to some time when they were the hottest that they can remember. Have them each tell, very briefly, about this time. Ask them if they sweated. Tell them that sweat comes out of tiny pores in their skin. Introduce stomata by asking if they think plants have pores. Transpiration through stomata cools a plant, just like sweating cools us and some other animals. (Another option for this introduction: Have the children hold out their hands. Look to see who has the wrinkliest skin. Ask why someone's hands would be wrinkly. Relate water loss through skin pores to plant water loss by transpiration through leaf stomata.)

Discuss the desert climate around Moab, especially the low amount of rainfall, drying winds, and hot temperatures of the summer. The plants that live here have different adaptations to allow them to survive in this climate. Ask what time during a 24-hour day is the coolest. Some plants, such as cacti, open their stomata only at this coolest time, the nighttime.

2) Go on a hike and find a cactus. Review the idea that both perspiration in animals and transpiration in plants allow cooling. Describe the cacti adaptation of opening their stomata only at night, to reduce evaporation. Hike back to station base area.

3) Show students pictures of night-blooming plants in a field guide, and be sure that they notice that the flowers are light in color, to be seen better at night. Tell students that most of these flowers have strong smells, and that the main reason they bloom at night is that that is when their pollinators are out. Certain insects come out only at night, and they smell through their antennae.

4) Read *Night Life of the Yucca*, introducing it as a story about a nighttime insect and a night-blooming plant that couldn't live without each other. Review the story, and add that each species of yucca attracts a different species of yucca moth by its individual scent.

5) Ask one student to become a yucca moth. Blindfold him and give him a scent in a film canister. The other students become different species of yucca, and film canisters with different scents are distributed to them. The yuccas take turns letting the moth smell them (by handing him their canister), and the moth identifies his yucca species by smell. Let others have a turn at being the moth. Review night-time plant activities and reasons plants take advantage of this time.

EVALUATION

Have students create a rap about the relationship of yucca moths and yucca plants.

OBJECTIVES

Students will be able to:
- Name two plants that have night-time adaptations.
- Describe the relationship between an evening-blooming yucca and a yucca moth.

MATERIALS

- Photos of night-blooming plants (e.g. Nelson, 1976)
- Blindfold
- Smells on small sponges in film canisters (two canisters of each smell)
- *Night Life of the Yucca* (Hauth, 1996)

TIME

- 30 minutes

STATION 4

Objectives

Students will be able to:
- Demonstrate an understanding of the concept of adaptation by imagining and drawing two adaptations and explaining how they help an imaginary plant to survive.

Materials

- Unlined paper

Time

- 30 minutes

POST-TRIP ACTIVITY

Adaptation art

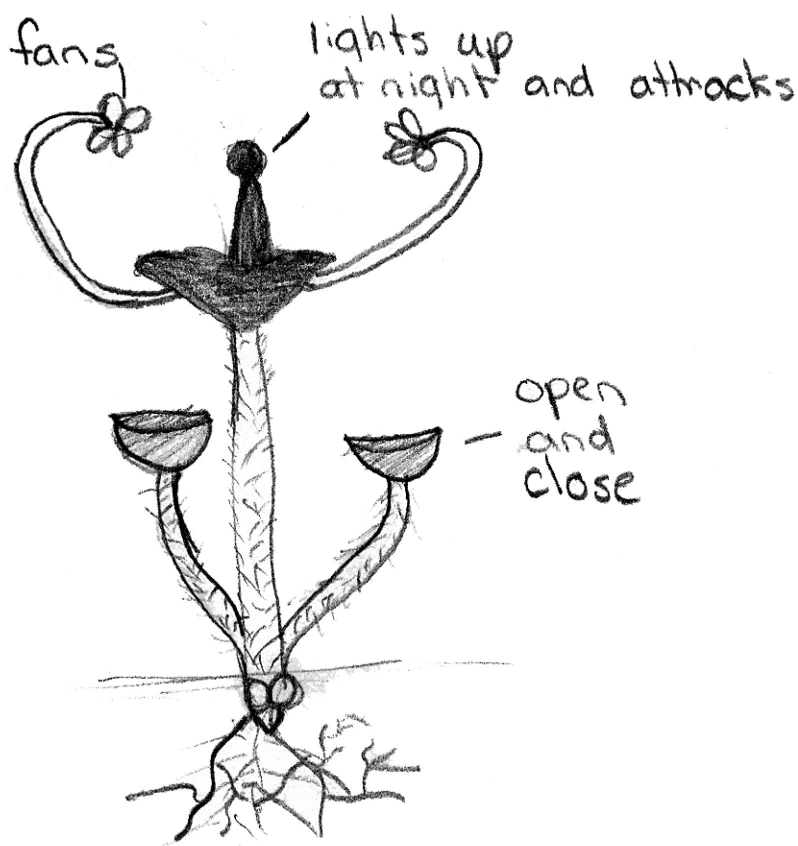
From Project WILD 1992, 114-115

PROCEDURE

1) Draw a generic plant on the board and label its parts. Review some of the plant adaptations that students learned about on the field trip. Discuss how the adaptations help the plants to survive.

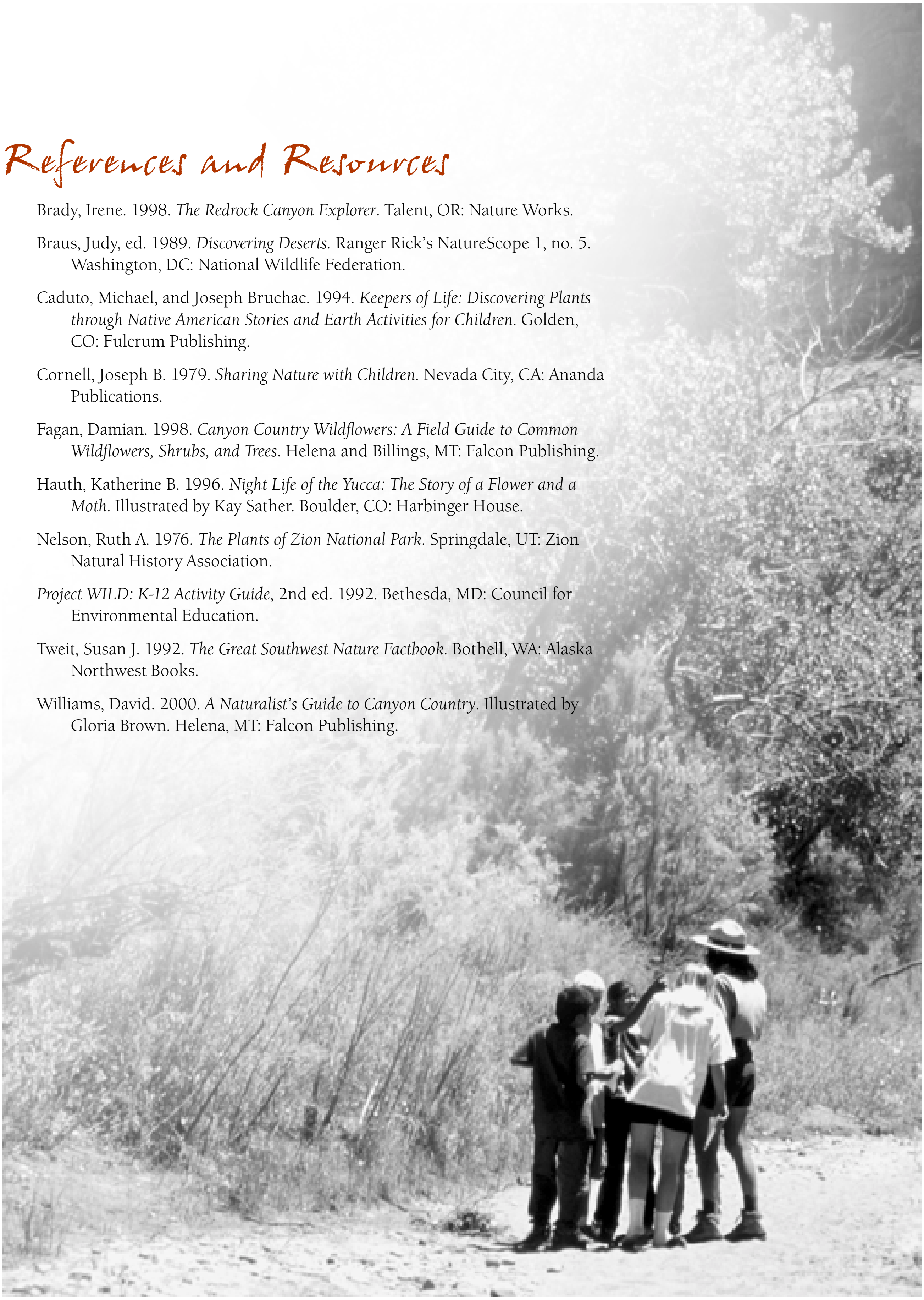
2) Ask students to create and draw an imaginary plant. Have each student think up three strategies or adaptations that their plant has, to survive in whatever environment they choose for it to live in. Ask them each to write the adaptations on the bottom of their page, along with where the plant lives and its proposed name.

3) Have volunteer students present their imaginary plants to the class, explaining specific adaptations and how they help the plants to survive in their unique environments.



BRITTNIE WHIPPLE

POST-TRIP



References and Resources

Brady, Irene. 1998. *The Redrock Canyon Explorer*. Talent, OR: Nature Works.

Braus, Judy, ed. 1989. *Discovering Deserts.* Ranger Rick's NatureScope 1, no. 5. Washington, DC: National Wildlife Federation.

Caduto, Michael, and Joseph Bruchac. 1994. *Keepers of Life: Discovering Plants through Native American Stories and Earth Activities for Children*. Golden, CO: Fulcrum Publishing.

Cornell, Joseph B. 1979. *Sharing Nature with Children*. Nevada City, CA: Ananda Publications.

Fagan, Damian. 1998. *Canyon Country Wildflowers: A Field Guide to Common Wildflowers, Shrubs, and Trees*. Helena and Billings, MT: Falcon Publishing.

Hauth, Katherine B. 1996. *Night Life of the Yucca: The Story of a Flower and a Moth*. Illustrated by Kay Sather. Boulder, CO: Harbinger House.

Nelson, Ruth A. 1976. *The Plants of Zion National Park*. Springdale, UT: Zion Natural History Association.

Project WILD: K-12 Activity Guide, 2nd ed. 1992. Bethesda, MD: Council for Environmental Education.

Tweit, Susan J. 1992. *The Great Southwest Nature Factbook.* Bothell, WA: Alaska Northwest Books.

Williams, David. 2000. *A Naturalist's Guide to Canyon Country*. Illustrated by Gloria Brown. Helena, MT: Falcon Publishing.